[CONTRIBUTION NUMBER 1116, FROM THE STERLING CHEMISTRY LABORATORY, YALE UNIVERSITY]

Stereoisomerism of Isopulegol Hydrates and Some Analogous 1,3-Diols

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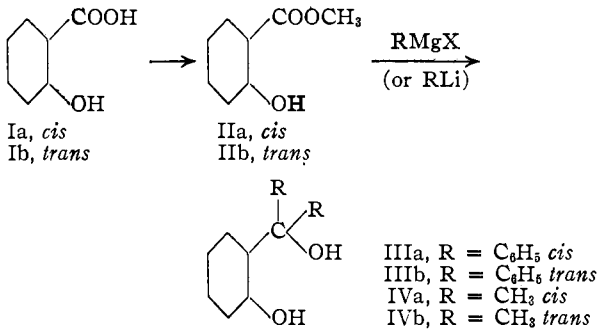
As a part of an investigation of the chemistry of 1,3-diols two sets of *cis-trans* isomeric 1,3-diols of the isopulegol hydrate type were prepared and the infrared spectra of these compounds and their hydroxy acid precursors were correlated. The cyclization of *d*-citronellal with 5% sulfuric acid to give isopulegol hydrate itself was studied and partial configurations of the two isomers obtained by us were assigned on the basis of their infrared spectra.

In continuing the study of the dehydration of 1,3-diols[1] it was of interest to prepare a series of *cis–trans* isomers of the isopulegol hydrate type, and then, by means of an infrared comparison with these synthetic analogs, to determine the *cis–trans* relationship of the groups at carbons three and four of the isopulegol hydrates (V) themselves. Since in the analogous case of the cyclization of *d*-citronellal to isopulegol it had already been demonstrated[2,3] that in the two isomeric products the groups at positions three and four bear a *cis–trans* relationship, it seemed likely *a priori* that the same would be true of the isomeric isopulegol hydrates prepared by a similar cyclization reaction.

For the preparation of synthetic analogs of isopulegol hydrate the known *cis*-[4–7] and *trans*-[8,9] 2-hydroxycyclohexanecarboxylic acids (Ia,b) served as convenient starting materials. *cis*-Methyl 2-hydroxycyclohexanecarboxylate (IIa) was prepared by high pressure hydrogenation of methyl salicylate. Under the present conditions the *cis*-ester was found to be the major product. Direct isomerization of IIa to *trans*-methyl 2-hydroxycyclohexanecarboxylate (IIb) by heating with sodium methylate, with or without methanol present, failed. However, *trans*-2-hydroxycyclohexanecarboxylic acid (Ib) was obtained by the method of Pascual, Sistare and Regas[5] which involved boiling the *cis*-acid Ia with concentrated aqueous potassium hydroxide. The same treatment of the *cis*-ester IIa proved to be more convenient, for it obviated the necessity of isolating the *cis*-acid Ia. The *trans*-methyl ester IIb was then prepared by Fischer esterification of the corresponding acid Ib.

Reaction of *cis*-methyl 2-hydroxycyclohexanecarboxylate (IIa) with methylmagnesium iodide gave *cis*-2-(α-hydroxyisopropyl)-cyclohexanol (IVa) in 36% yield, while the *trans*-isomer IIb with the same reagent gave *trans*-2-(α-hydroxyisopropyl)-cyclohexanol (IVb) in 43% yield. Reaction of phenylmagnesium bromide with the *cis*- and *trans*-esters, IIa and IIb, gave *cis*- and *trans*-2-(α-hydroxybenzhydryl)-cyclohexanol (IIIa) and (IIIb), respectively, in yields of 14 and 3%. Substitution of phenyllithium for phenylmagnesium bromide increased the yield of IIIb to 76%.

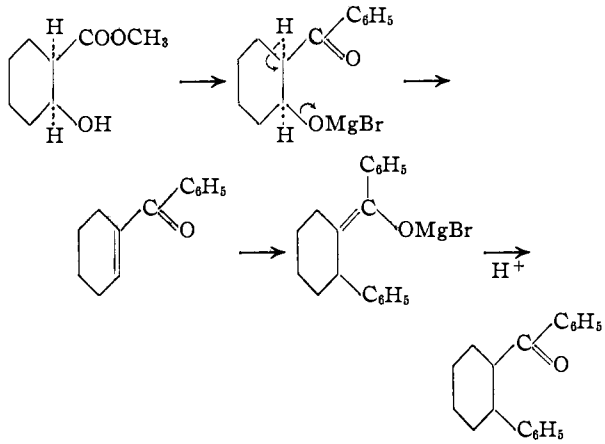


Ia, *cis*
Ib, *trans*

IIa, *cis*
IIb, *trans*

IIIa, R = C_6H_5 *cis*
IIIb, R = C_6H_5 *trans*
IVa, R = CH_3 *cis*
IVb, R = CH_3 *trans*

Also produced in the reaction of phenylmagnesium bromide with *cis*-methyl 2-hydroxycyclohexanecarboxylate was a substance believed to be 1-phenyl-2-benzoylcyclohexane (VI). This assumption is supported by carbon–hydrogen analysis and infrared spectrum. Moreover, it is reasonable to expect formation of this substance in the following manner.



These synthetic isopulegol hydrate analogs having been prepared, attention was turned to isopulegol hydrate itself. The cyclization of *d*-citronellal by 5% sulfuric acid has been reported by Barbier and Leser[10] and later by Doeuvre[11] to yield only one isomer of isopulegol hydrate; they reported melting points of 80–81° and 81–81.5°, respectively. Prins[12] obtained two isomers melting at 60–62° and 84–85° by cyclization of *d*-citronellal with formic acid. He considered the latter compound to be identical with that of the earlier workers. Grignard and Doeuvre[13] obtained material melting at 65–66° by carrying out the same reaction in acetic acid. Wallach,[14] using a

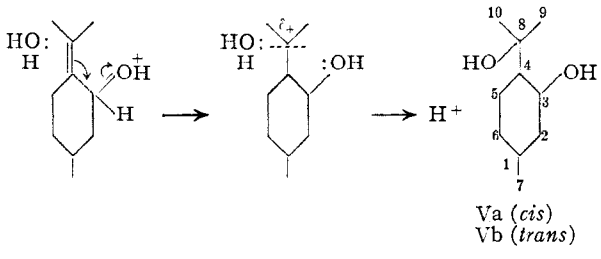
(1) F. W. Brutcher and J. English, Jr., THIS JOURNAL, **74**, 4279 (1952); Brutcher, Ph.D. Thesis, Yale University, 1951.
(2) R. H. Pickard and co-workers, *J. Chem. Soc.*, 1248 (1920).
(3) A. G. Short and J. H. Read, *ibid.*, 1306 (1939).
(4) E. R. Marshal, J. A. Kuck and R. C. Elderfield, *J. Org. Chem.*, **7**, 454 (1942).
(5) J. Pascual, J. Sistare and A. Regas, *J. Chem. Soc.*, 1943 (1949).
(6) K. Alder and M. Schumacher, *Ann.*, **565**, 148 (1949).
(7) H. J. Pistor and H. Plieninger, *ibid.*, **562**, 243 (1949).
(8) A. Einhorn and A. Meyenberg, *Ber.*, **27**, 2472 (1894).
(9) W. Dieckmann, *ibid.*, 2475 (1894).
(10) P. Barbier and G. Leser, *Compt. rend.*, **124**, 1308 (1897).
(11) J. Doeuvre, *Bull. soc. chim.*, **53**, 27 (1933).
(12) H. J. Prins, *Chem. Zentr.*, **88**, II, 289 (1917).
(13) V. Grignard and J. Doeuvre, *Compt. rend.*, **187**, 272 (1928).
(14) O. Wallach, *Ann.*, **360**, 102 (1908).

different approach, reported isopulegol hydrate, m.p. 75°, from the hydration of isopulegol with dilute sulfuric acid.

In the present work *d*-citronellal was cyclized to isopulegol hydrate (V) by stirring with 5% sulfuric acid for 27 hours, essentially as described by Barbier and Leser.[10,11] The oily reaction product yielded two crystalline isomers on careful fractional distillation with a Stedman column. These melted at 61 and 74° and their melting points were not changed by continued recrystallization. Repetition of the experiment using citronellal from another commercial source yielded the same products. We were unable to isolate any of the 81° isomer which was the sole crystalline product isolated by some of the earlier workers[10,11] under these conditions. That the gross structure of the isomers obtained is represented by V is indicated by the mode of formation (both by cyclization of citronellal and by hydration of isopulegol), by evidence in the literature[10-14] and by the infrared data given below.

Examination of the 16 approximately equal fractions obtained on distillation of the crude isopulegol hydrate mixture showed that the infrared spectra of fractions 3–11 were identical, and that 13–15 were indistinguishable from one another but different from the earlier cuts. Fractions 3–11 were solid and gave the compound, m.p. 61°, after recrystallization and fractions 13, 14 and 15 similarly yielded the isomer, m.p. 74°. The infrared spectra of these compounds did not change on recrystallization. Attempts to obtain other pure isomers from the remaining fractions by crystallization led only to these same substances or to oily products.

More than twice as much of the isomer, m.p. 61°, was obtained as of the isomer, m.p. 74°. This is of special interest, since the lower melting (61°) compound is shown (note infrared discussion to follow) to be *cis*-(Va) and the higher melting (74°) isomer, to be *trans*-(Vb) with respect to the 3-hydroxyl- and the 4-hydroxyisopropyl groups. This preferential formation of the *cis* isomer may be rationalized on the basis of a lower energy transition state for the *cis* compound, in which the C_3-hydroxyl oxygen can more effectively solvate a positive center at C_8. The mechanism of cyclization is then visualized as



Va (*cis*)
Vb (*trans*)

The intermediate may be considered to be a protonated, solvated trimethylene oxide as suggested by Brutcher[1] for the cleavage of 1,3-diols. The mechanism proposed is then an elaboration of that suggested for the Prins reaction by Price[15] and is compatible with the report that cyclization of citronellal in acidic ethanol gives 3-hydroxy-8-ethoxy-*p*-menthane,[16] for here the over-all mechanism can be represented in an analogous manner.

A detailed examination of the infrared spectra of the compounds in this series has proved instructive. For the purpose of assigning configurations to Va and Vb the spectra of these compounds were compared with those of the analogous IVa and IVb. The 7 μ to 9.5 μ region of Va is very similar to that of IVa, which is known to be *cis*, while that of Vb is like that of the *trans*-IVb. In examination of the spectra of Ia, Ib, IIIa, IIIb, IVa, IVb, Va, Vb (Table I) several points are apparent.

TABLE I

Compound	Band A, μ	Band B, μ	Band C, μ	Band D, μ
Ia(*cis*)	9.44(wk.)		10.28(str.)	
IIIa(*cis*)	Abs.		10.28(str.)	9.39(str.)
IVa(*cis*)	9.46(wk.)	8.60(str.)	10.30(str.)	
		8.70(med.)		
Va(*cis*)	Abs.	8.61(str.)	10.10(wk.)	
		8.84(med.)	10.38(med.)	
Ib(*trans*)	9.44(med.)		10.07(med.)	
IIIb(*trans*)	9.47(str.)		9.96(str.)	9.37(str.)
IVb(*trans*)	9.48(str.)	8.40(med.)	10.06(str.)	
		8.65(str.)		
Vb(*trans*)	9.51(med.)	8.46(str.)	10.00(str.)	
		8.65(str.)	10.25(med.)	
			10.35(med.)	

The secondary carbon–oxygen stretching bands,[17] which appear at 9.44 to 9.51 μ, are either weak or missing in the *cis* isomers (Ia, IIIa, IVa, Va) while the *trans* isomers show strong absorption in this region. The tertiary carbon–oxygen stretching bands[17] which appear as double absorption bands at 8.40–8.84 μ occur at longer wave length in the case of *cis* isomers. Also, a strong absorption band appears at 10.28–10.30 μ, in the case of the *cis* isomers Ia, IIIa and IVa while the corresponding *trans* isomers absorb in the region 9.96–10.07 μ. This may also be a secondary carbon–oxygen absorption band.[18]

Study of these compounds in the 2.0–3.2 μ region in dilute solution with a lithium fluoride prism[19] yields information on the importance of intramolecular hydrogen bonding in these compounds and supports the assignment of configurations to Va and Vb (note Table II). It is found that intramolecular hydrogen bonding is stronger (*i.e.*, $\Delta\nu$ greater) in the *trans* compounds IVb and Vb than in the *cis* isomers IVa and Va.[19] This is plausible since in the *trans* isomer IVb both hydroxyl and carbinol groups may occupy the less hindered equatorial positions.[20] It is also of interest to note that hydrogen bonded structure of

(15) C. C. Price, *Ind. Eng. Chem.*, **40**, 257 (1948).

(16) Laboratoire "Dauphin," *C. A.*, **22**, 2239 (1928).

(17) Assignment of these bands as due to secondary and tertiary carbon–oxygen stretching is made on the basis of a report by W. Weniger (*Phys. Rev.*, **31**, 412 (1910)) that the secondary hydroxyl absorption bands appear in the 9.1 μ region and the tertiary hydroxyl bands at 8.6 μ. These assignments are in agreement with the recent results of H. H. Zeiss and M. Tsutsui, (THIS JOURNAL, **75**, 897 (1953)).

(18) The secondary carbon–oxygen stretching band of certain C_3-sterols has been reported by A. H. R. Cole, R. Norman Jones and K. Dobriner, THIS JOURNAL, **74**, 5571 (1952), to appear as high as 10 μ. While in rigid molecules one might expect only one C–O absorption band, more than one band might be possible when several molecular conformations are possible, as in the present case.

(19) The method used is essentially that of L. Kuhn, *ibid.*, **74**, 2492 (1952), and the assignments of free OH and bonded OH bands are made on the basis of his correlations.

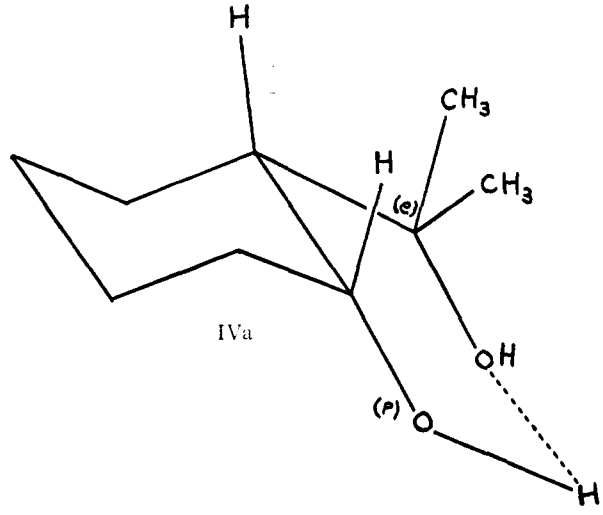
(20) D. H. R. Barton, *Experientia*, **6**, 316 (1950).

TABLE II

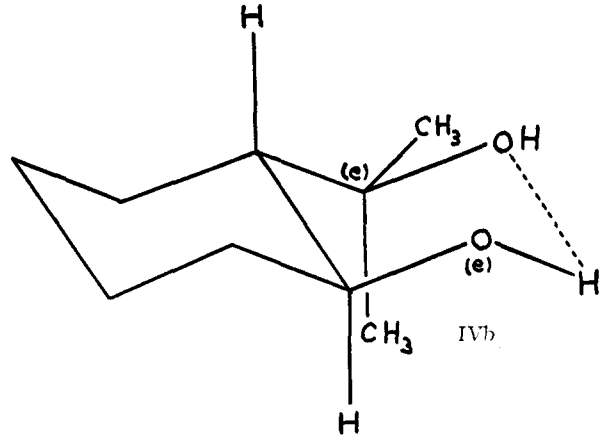
Compound	Free OH (ν cm.$^{-1}$)	Intramolec. bonded OH (cm.$^{-1}$)	Intermolec. bonded OH (cm.$^{-1}$)	$\Delta\nu$ (cm.$^{-1}$)
Ia	[a]	3522	..	
Ib	3605	3527	..	78
IIIa	3623	3472	..	151
IIIb	3618, 3598	(3508)[b], 3472	..	
IVa	3617	3523	..	94
IVb	3612	3507	3324	105
Va	3617	3522	..	95
Vb	3612	3506	3322	106

[a] No peak, but over-all absorption. [b] Plateau, not resolved as second peak.

IVb is essentially a *trans*-fused bicyclic system, analogous to that in the decalin series for example, which in general seem thermodynamically more stable than the *cis* isomers. Table II shows the close relationship between the *cis* isomers (IVa and Va) and that between the *trans* compounds (IVb and Vb).



IVa



IVb

Experimental

cis-**Methyl 2-Hydroxycyclohexanecarboxylate (IIa).**—The hydrogenation of methyl salicylate in alcoholic media with Raney nickel has been reported by several workers.[4,7,21] The following modified method was used: 125 ml. of methyl salicylate with 10 g. of Raney nickel (W-2)[22] was hydrogenated in a 300 cm.^{3} rocking steel bomb at 175° at 2000 lb./in.^{2} pressure. At the end of ten hours the rate of hydrogenation was negligible and the uptake approximated 90% of theoretical. Centrifugation and distillation yielded 96.9 g., b.p. 106–110° at 13 mm., and 23.2 g. of non-distilled polyester which gave Ia on saponification.

cis-**2-Hydroxycyclohexanecarboxylic Acid.**[4–7]—*cis*-2-Hydroxycyclohexanecarboxylic acid was obtained by saponification with 10% NaOH. The highest yield obtained was 75%; however, the yields were usually closer to 50%. The melting point after one recrystallization from ethyl acetate was 73–75°, and further recrystallization brought the melting point to 77–78°. Previous investigators have reported 76–78°,[4] 80–81°,[5] 82–83°,[6] 75–77°.[7]

trans-**2-Hydroxycyclohexanecarboxylic Acid**[8,9] **(Ib).**—Conversion of Ia to Ib by refluxing with a large excess of 10 *N* potassium hydroxide for 40 hours[3] yielded crude *trans*-acid Ib in 60% yield. Two recrystallizations from ethyl acetate brought the melting point to 109–110°; reported m.p. 110–111°.[5] *cis*-Methyl 2-hydroxycyclohexanecarboxylate could be converted directly to Ib by the same procedure. The yields were improved in each case by concentration of the alkaline solution of the potassium salt before acidification with concentrated HCl and saturation with ammonium sulfate before ether extraction of the product. *cis*-Acid Ia could occasionally be recovered from the mother liquors of the ethyl acetate recrystallization.

trans-**Methyl 2-Hydroxycyclohexanecarboxylate**[5] **(IIb).**—Esterification of 110 g. of *trans*-2-hydroxycyclohexanecarboxylic acid by refluxing with 500 ml. of methanol and 5 ml. of concentrated sulfuric acid for ten hours yielded 84.0 g. of *trans*-methyl ester IIb, b.p. 108–109° (10 mm.).

The direct conversion of IIa to IIb by heating IIa with sodium methoxide either with or without solvent, was unsuccessful.

cis-**2-(α-Hydroxyisopropyl)-cyclohexanol (IVa).**—To one mole of methylmagnesium iodide formed in the usual manner in 350 ml. of ether was added with stirring over 1.75 hours a solution of 39.5 g. (0.25 mole) of *cis*-methyl 2-hydroxycyclohexanecarboxylate (IIa) in 100 ml. of ether. The ether extracts were washed with dilute sodium carbonate solution and dried over sodium sulfate. After removal of the ether the residue was distilled to give 14.4 g., b.p. 86–88° (18 mm.) (bath temp. 109–112°). This fraction crystallized on standing. Recrystallization from petroleum ether (30–60°) brought the melting point to 52–54°.

Anal. Calcd. for $C_9H_{18}O_2$: C, 68.31; H, 11.47. Found: C, 68.33; H, 11.47.

trans-**2-(α-Hydroxyisopropyl)-cyclohexanol (IVb).**—The reaction of 39.5 g. (0.25 mole) of *trans*-methyl 2-hydroxycyclohexanecarboxylate IIb in 100 ml. of ether with one mole of methylmagnesium iodide in 350 ml. of ether was carried out in the same manner as in the preparation of IVa, except that after removal of the ether the product crystallized out nicely and distillation was not necessary. The crude product weighed 21.5 g. Two recrystallizations from 20-ml. portions of petroleum ether 30–90° yielded 17.3 g. of IVb, m.p. 76.7°.

Anal. Calcd. for $C_9H_{18}O_2$: C, 68.31; H, 11.47. Found: C, 68.25; H, 11.48.

cis-**2-(α-Hydroxybenzhydryl)-cyclohexanol (IIIa).**—Seventy-nine grams (0.5 mole) of *cis*-methylcyclohexanecarboxylate (IIa) in 50 ml. ether was added with stirring over three hours to 2.0 moles of phenylmagnesium bromide in 750 ml. of ether. After standing two hours at room temperature the product was worked up in the usual manner and after the ether was removed 109.3 g. of slightly oily solid remained. Several recrystallizations from ethanol yielded 19.2 g. of IIIa, m.p. 178–179.5°.

Anal. Calcd. for $C_{19}H_{22}O_2$: C, 80.81; H, 7.85. Found: C, 80.76; H, 7.92.

The filtrates yielded after fractional crystallization from ethanol two substances, m.p. 116–117.5° and m.p. 139.5–142°. The infrared spectrum and a carbon–hydrogen analysis showed the former to be most likely 1-phenyl-2-benzoylcyclohexane. The infrared spectrum had a carbonyl absorption band at 5.95 μ, indicating the presence of benzoyl, and absorption bands at 6.23 and 6.30 μ whose intensity made it likely that more than one phenyl group was present. No hydroxyl or conjugated double bond absorption was detectable.

(21) R. Connor and H. Adkins, THIS JOURNAL, **54**, 4678 (1932).
(22) *Org. Syntheses*, **21**, 15 (1941).

Anal. Calcd. for $C_{19}H_{20}O$: C, 86.32; H, 7.63. Found: C, 86.42; H, 7.61.

Carbon–hydrogen analysis and the infrared spectrum showed the 139.5–142° compound to be a mixture of the two isomers IIIa and IIIb.

Anal. Calcd. for $C_{19}H_{22}O_2$: C, 80.81; H, 7.85. Found: C, 81.05; H, 8.00.

trans-2-(α-Hydroxybenzhydryl)-cyclohexanol (IIIb).—The same procedure used in the preparation of IIIa applied here to 5.0 g. of *trans*-methyl-2-hydroxycyclohexanecarboxylate yielded after recrystallization only 0.30 g. of IIIb, m.p. 161–162°.

Anal. Calcd. for $C_{19}H_{22}O_2$: C, 80.81; H, 7.85. Found: C, 80.88; H, 7.96.

Also isolated was 0.60 g. of a compound, m.p. 131–133° (m.p. not changed by further recrystallization) whose analysis and infrared spectrum showed it to be either a crystalline modification of IIIb or IIIb with a depressed melting point due to a small amount of impurity not removed by recrystallization and not apparent in the infrared spectrum.

Anal. Calcd. for $C_{19}H_{22}O_2$: C, 80.81; H, 7.85. Found: C, 80.60; H, 7.91.

Addition of 15.8 g. (0.1 mole) of *trans*-methyl 2-hydroxycyclohexanecarboxylate (IIb) in 50 ml. ether to 0.5 mole of phenyllithium in 300 ml. of ether was made with stirring over 2.25 hours. The crude yield of IIIb weighed 24.6 g. Several recrystallizations yielded 20.8 g., m.p. 160.5–161.0°.

cis- and *trans*-Isopulegol Hydrate (Va) and (Vb). Internal Prins Reaction of *d*-Citronellal.—Two hundred grams of *d*-citronellal (Matheson Co.), $[\alpha]^{24}D$ 10.4°, was stirred with 1000 ml. of 5% sulfuric acid at room temperature for 27 hours. Some cooling was necessary initially. The organic phase was removed with ether and the ether extracts were washed with water and then 5% sodium carbonate and finally dried over sodium sulfate. The ether was removed and the residual water removed by distillation with benzene. The remaining thick oil was distilled to give 180 ml., b.p. 102–106° at 0.3–0.6 mm. This was fractionated in a 2-foot Stedman column (approx. 50 theor. plates) to give sixteen fractions. Fractions 3 to 11 (b.p. 129–133° at 5 mm.) and also 13 to 15 (b.p. 136–142° at 5 mm.) solidified. The infrared spectra of all the former (3 to 11) were identical and of all the latter (13 to 15) corresponded to a different homogeneous compound. Recrystallization of the former yielded pure *cis*-isopulegol hydrate, m.p. 61–62° (this isomer was obtained under different circumstances by Prins[12]). The latter gave *trans*-isopulegol. The yields were 90.86 g. of the *cis* compound, m.p. 61–62°, and only 39.86 g. of the *trans* isomer, m.p. 75°. Fraction 16 (b.p. 142° at 5 mm.) was slightly oily; it weighed 3.10 g. and yielded only the isomer m.p. 75° on recrystallization.

Anal. Va Calcd. for $C_{19}H_{20}O_2$: C, 69.72; H, 11.70. Found: C, 69.84; H, 11.88. *Anal.* Vb Calcd. for $C_{10}H_{22}O_2$: C, 69.72; H, 11.70. Found: C, 69.50; H, 11.90.

Infrared spectra were obtained with a Perkin–Elmer model 21 spectrophotometer in chloroform solution. Spectra in the 2–3 μ region in dilute solution were run in carbon tetrachloride at 0.005 *M* except for compound IIIa which was run at 0.002 *M*. A 23-mm. glass cell equipped with NaCl plates was used. The accuracy varies from ±1 $cm.^{-1}$ for the sharp free OH bands to a slightly greater error in the case of the broader bonded OH bands.

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[CONTRIBUTION FROM THE AVERY LABORATORY OF THE UNIVERSITY OF NEBRASKA]

Studies in the Furan Series. Chloralfuramides and Some of their Reactions

BY JOE R. WILLARD[1] AND CLIFF S. HAMILTON

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2-Furamide, 5-bromo-2-furamide, 5-methyl-2-furamide, 5-nitro-2-furamide, 5-*t*-butyl-2-furamide and β-(2-furyl)-acrylamide were added to chloral to form the corresponding 1-(amido)-2,2,2-trichloroethanols. The benzoates of 1-(2-furamido)- and 1-(5-bromo-2-furamido)-2,2,2-trichloroethanols were prepared. 1-(2-Furamido)-, 1-(5-bromo-2-furamido)-, 1-(5-nitro-2-furamido)- and 1-(5-*t*-butyl-2-furamido)-2,2,2-trichloroethanols reacted with phosphorus pentachloride to give the corresponding 1-(furamido)-1,2,2,2-tetrachloroethanes. These tetrachloroethanes were then treated with various alcohols, ammonia and amines to yield the corresponding 1-(furamido)-1-alkoxy-, -1-amino-, -1-arylamino- and -1-alkylamino-2,2,2-trichloroethanes. Reaction of 1-(2-furamido)- and 1-(5-bromo-2-furamido)-1,2,2,2-tetrachloroethanes with ammonia gave the corresponding bis-(1-furamido-2,2,2-trichloroethyl)-amines.

While the reaction of amides with chloral has been known for a long time and many "chloralamides" have been prepared,[2] no heterocyclic amides have been added to chloral. Therefore, the addition of some 2-furamides to chloral was investigated and some studies of the resulting chloralfuramides were made.

2-Furamide, 5-bromo-2-furamide, 5-methyl-2-furamide, 5-nitro-2-furamide, 5-*t*-butyl-2-furamide and β-(2-furyl)-acrylamide reacted readily with anhydrous chloral in the absence of catalysts to give a stable crystalline solid in each case. The properties of these chloralamides are indicated in Table I.

As was reported by Chattaway[3] in studies on monosubstituted ureas, N-substituted furamides (N-benzyl- and N-methyl-2-furamide) did not react under the conditions employed for the above amides.

While many chloralamides have been acylated by the action of benzoyl chloride in 10% aqueous sodium hydroxide,[4] this method was not successful in the case of 1-(2-furamido)- or 1-(5-bromo-2-furamido)-2,2,2-trichloroethanol. The benzoyl derivatives of the latter compounds were, however, obtained by the action of benzoyl chloride in excess pyridine. Attempts to acetylate these chloralfuramides using acetic anhydride with excess pyridine, aqueous sodium hydroxide or sodium acetate solution were unsuccessful, yielding only unreacted starting material, non-crystallizable oil or the corresponding furoic acid. Similarly, attempts to methylate the chloralfuramides using dimethyl sulfate in excess aqueous sodium acetate or sodium hydroxide solution yielded only unreacted starting material or the corresponding furoic acid.

The chlorination of the 1-(furamido)-2,2,2-

(1) Parke, Davis and Company Fellow. Present address: Research and Development Department, Westvaco Chemical Division, Food Machinery and Chemical Corp., So. Charleston, W. Va.

(2) A. N. Meldrum and M. J. Bhojraj, *J. Indian Chem. Soc.*, **13**, 185 (1936); N. W. Hirwe, *J. Univ. Bombay*, **6II**, 182 (1937).

(3) F. D. Chattaway and E. J. James, *Proc. Roy. Soc. (London)*, **A134**, 372 (1931).

(4) N. W. Hirwe and K. D. Gavankar, *J. Univ. Bombay*, **6II**, 123 (1937).